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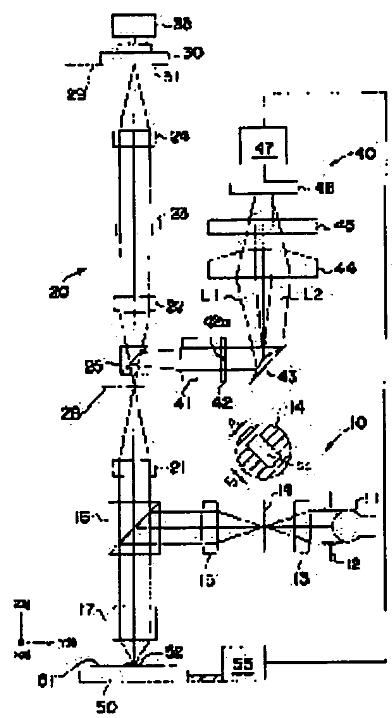
(54) APPARATUS AND METHOD FOR ADJUSTING OPTICAL POSITION DEVIATION MEASURING APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To simply adjust an optical system of an overlay position deviation measuring apparatus.

SOLUTION: The optical position deviation measuring apparatus is composed of an illumination optical system 10 for illuminating a measuring mark 52; an image-forming optical system 20 for condensing reflected light from the measuring mark to form an image of the measuring mark; a CCD camera 30 for taking the image of the measuring mark formed by the image forming optical system; and an image processor 35 for measuring the position deviation of the measuring mark from obtained image signals and auto-focusing unit 40 for auto-focusing adjustments. This apparatus performs auto-focusing adjustment, adjustment of an image-forming aperture orifice 23 of the image forming optical system 20, an adjustment of a second objective lens 21 and an adjustment of an illumination aperture orifice 12 of the illumination optical system 10 in this order for adjusting errors in measurement.



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CLAIMS

[Claim(s)]
[Claim 1] The illumination-light study system which illuminates a measurement mark, and the image formation optical system to which the reflected light from said measurement mark is condensed, and image formation of the image of said measurement mark is carried out, The image pick-up equipment which photos the image of said measurement mark in which image formation was carried out by said image formation optical system, In the optical location gap measuring device constituted by having the image processing system which processes the picture signal acquired by said image pick-up equipment, and measures a location gap of said measurement mark The adjusting device of the optical location gap measuring device characterized by being constituted so that justification of two or more optical elements which constitute said illumination-light study system and said image formation optical system may be constituted possible, may justify said two or more optical elements in predetermined sequence and may perform measurement error adjustment.
[Claim 2] said measurement error adjustment -- said measurement mark -- replacing with -- two or more parallel lines -- the adjusting device according to claim 1 characterized by being carried out based on QZ curve obtained using the last shipment mark which consists of a mark.
[Claim 3] Illuminate said last shipment mark by said illumination-light study system, and the image of said last shipment mark by which image formation was carried out by condensing the reflected light according to said image formation optical system is photoed with said image pick-up equipment. The adjusting device according to claim 2 characterized by calculating the Q value which processes the acquired picture signal with said image processing system, and shows the sex for un-of said last shipment mark, and calculating said QZ curve from said Q value which is made to move said last shipment mark in the direction of an optical axis (Z direction), and is obtained.
[Claim 4] The adjusting device according to claim 1 to 3 characterized by said two or more optical elements consisting of a lighting aperture diaphragm which constitutes said illumination-light study system, and the objective lens and image formation aperture diaphragm which constitute said image formation optical system.
[Claim 5] The adjusting device according to claim 4 characterized by setting up said predetermined sequence so that said image formation aperture diaphragm may be justified first, then said objective lens may be justified and said lighting aperture diaphragm may finally be justified.
[Claim 6] Claim 4 characterized by performing adjustment which carries out flattening of the convex configuration of said QZ curve by justification of said image formation aperture diaphragm, performing adjustment to which the inclination of said QZ curve is changed by justification of said objective lens, and performing adjustment which makes the parallel shift migration of said QZ curve carry out in the direction of Q value by justification of said lighting aperture diaphragm, or an adjusting device given in 5.
[Claim 7] Claim 5 characterized by performing said justification automatically, or an adjusting device given in 6.
[Claim 8] The adjusting device according to claim 1 to 3 characterized by branching from said image formation optical system, and forming the automatic focus equipment which performs automatic focus adjustment when photoing the image in which image formation was carried out by said image formation optical system with said image pick-up equipment.
[Claim 9] The adjusting device according to claim 8 characterized by to set up said predetermined sequence so that two or more of said optical elements may consist of a lighting aperture diaphragm which constitutes said illumination-light study system, and the objective lens and the image-formation aperture diaphragm which

constitute said image-formation optical system, may perform automatic-focus adjustment by said automatic-focus equipment to the beginning, may justify said image-formation aperture diaphragm to the second, may justify said objective lens to the third and may finally justify said lighting aperture diaphragm.
[Claim 10] The adjusting device according to claim 9 characterized by repeating again said automatic focus adjustment, justification of said image formation aperture diaphragm, justification of said objective lens, and justification of said lighting aperture diaphragm in order of predetermined [said], and performing them when said Q value does not fall within a predetermined range after justifying said lighting aperture diaphragm at the end.
[Claim 11] Claim 9 characterized by performing again automatic focus adjustment by said automatic focus equipment after justifying said lighting aperture diaphragm at the end, or an adjusting device given in 10.
[Claim 12] The adjusting device according to claim 9 to 11 characterized by performing automatically said automatic focus adjustment and said justification.
[Claim 13] The illumination-light study system which illuminates a measurement mark, and the image formation optical system to which the reflected light from said measurement mark is condensed, and image formation of the image of said measurement mark is carried out, The image pick-up equipment which photos the image of said measurement mark in which image formation was carried out by said image formation optical system, In the optical location gap measuring device constituted by having the image processing system which processes the picture signal acquired by said image pick-up equipment, and measures a location gap of said measurement mark The adjustment approach of the optical location gap measuring device characterized by justifying two or more optical elements which constitute said illumination-light study system and said image formation optical system in predetermined sequence, and performing measurement error adjustment.
[Claim 14] said measurement error adjustment -- said measurement mark -- replacing with -- two or more parallel lines -- the adjustment approach according to claim 13 characterized by being carried out based on QZ curve obtained using the last shipment mark which consists of a mark.
[Claim 15] Illuminate said last shipment mark by said illumination-light study system, and the image of said last shipment mark by which image formation was carried out by condensing the reflected light according to said image formation optical system is photoed with said image pick-up equipment. The adjustment approach according to claim 14 characterized by calculating the Q value which processes the acquired picture signal with said image processing system, and shows the sex for un-of said last shipment mark, and calculating said QZ curve from said Q value which is made to move said last shipment mark in the direction of an optical axis (Z direction), and is obtained.
[Claim 16] The adjustment approach according to claim 13 to 15 characterized by for said two or more optical elements consisting of a lighting aperture diaphragm which constitutes said illumination-light study system, and the objective lens and image formation aperture diaphragm which constitute said image formation optical system, justifying said image formation aperture diaphragm first, then justifying said objective lens, and finally justifying said lighting aperture diaphragm.
[Claim 17] The adjustment approach according to claim 16 characterized by for it to branch from said image-formation optical system, and for the automatic-focus equipment which performs automatic-focus adjustment when photoing the image in which image formation was carried out by said image formation optical system with said image pick-up equipment to be formed, to perform automatic-focus adjustment by said automatic-focus equipment to the beginning, to justify said image-formation aperture diaphragm to the second, to justify said objective lens to the third, and finally to justify said lighting aperture diaphragm.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the equipment and the approach of adjusting this optical location gap measuring device in more detail in the photolithography production process of a semi-conductor wafer etc. about the optical location gap measuring device used in order to measure optically a location gap (superposition location gap) of the resist mark to Mark Shimoji in the measurement mark (superposition mark) formed on examined substrates, such as a semi-conductor wafer.
[0002]
[Description of the Prior Art] In the photolithography production process which is one of the production processes of a semiconductor chip, on a wafer, it is divided into several steps and a resist pattern is formed. Namely, a predetermined resist pattern is piled up and formed on the pattern (this is called a substrate pattern) already formed for every phase. Since the desired engine performance is not obtained, it requires exact superposition positioning that the location of the resist pattern formed in piles to a substrate pattern shifted at this time. Since it is such, it is required that the superposition location gap of a resist pattern to a substrate pattern should be measured for every formation phase of a resist pattern, and the equipment for this superposition location gap measurement is known from the former (for example, refer to JP,2000-77295,A).
[0003] On Mark Shimoji who formed on the substrate at the time of resist pattern formation, this superposition location gap measurement forms a resist mark, and forms the measurement mark. An optical location gap measuring device (superposition location gap measuring device) is used. While irradiating the illumination light at a measurement mark, from the reflected light, the image of a measurement mark is picturized with a CCD camera etc., the image processing of the picturized image is carried out, and the amount of superposition location gaps of the resist mark to Mark Shimoji is measured.
[0004] By the way, when superposition location gap measurement is performed optically in this way, It is not avoided that optical aberration occurs in a measuring beam study system (namely, condensing optical system which carries out condensing image formation of the illumination-light study system which irradiates the illumination light, and the reflected light from a measurement mark to a measurement mark). If aberration symmetrical with nonrotation exists in a measurement visual field field to such aberration, especially an optical axis, the measurement error TIS (Tool Induced Shift) of superposition location gap measured value will arise.
[0005] In having performed superposition location gap measurement, with such a measurement error TIS existed, there is a problem that exact location gap measurement cannot be performed. For this reason, before performing location gap measurement using an optical location gap measuring device, it is proposed from the former that the lighting aperture diaphragm used for the measuring beam study system of this equipment, an image formation aperture diaphragm, an objective lens, etc. are justified, and it is [it does not come out of it and] made to carry out a measurement error TIS (for example, refer to JP,2000-77295,A).
[0006]
[Problem(s) to be Solved by the Invention] However, adjustment elements, such as a lighting aperture diaphragm, an image formation aperture diaphragm, and an objective lens, are difficult for removing a measurement error TIS only by any one, and it is necessary to adjust combining the adjustment element of these plurality suitably, and to remove a measurement error TIS. And in order that the adjustment element of these plurality may do effect mutually, there may be and it may change a measurement error TIS delicately, it has the problem that it is very difficult to combine adjustment of the adjustment element of these plurality

appropriately.
[0007] Furthermore, automatic focus optical system is included in the measuring beam study system of a superposition location gap measuring device in many cases, and there is a problem that automatic focus optical system also needs to be adjusted for the removal adjustment and coincidence of a measurement error TIS by adjustment of two or more above-mentioned adjustment elements, and such tuning is complicated further.
[0008] This invention is what took the example by such problem, and it aims at enabling it to perform simply tuning of the optical system of a superposition location gap measuring device. This invention aims at enabling it to perform automatically tuning of the optical system of a superposition location gap measuring device again.
[0009]
[Means for Solving the Problem] The illumination-light study system in which this invention illuminates a measurement mark for such purpose achievement, The image formation optical system to which the reflected light from this measurement mark is condensed, and image formation of the image of a measurement mark is carried out, The image pick-up equipment which photos the image of the measurement mark in which image formation was carried out by this image formation optical system, In the optical location gap measuring device constituted by having the image processing system which processes the picture signal acquired by this image pick-up equipment, and measures a location gap of a measurement mark An adjusting device is constituted so that an optical element nothing and multiple [these] may be justified for justification of two or more optical elements which constitute an illumination-light study system and image formation optical system in predetermined sequence with it being possible and measurement error adjustment may be performed.
[0010] in addition, this measurement error adjustment -- a measurement mark -- replacing with -- two or more parallel lines -- it is carried out based on QZ curve obtained using the last shipment mark which consists of a mark. This QZ curve illuminates a last shipment mark by the illumination-light study system, calculates the Q value which photos the image of the last shipment mark by which image formation was carried out by condensing that reflected light according to image formation optical system with image pick-up equipment, processes the acquired picture signal with an image processing system, and shows the sex for un-of a last shipment mark, moves a last shipment mark in the direction of an optical axis (Z direction), and is obtained.
[0011] As two or more optical elements to which justification is performed in this invention, there are a lighting aperture diaphragm which constitutes an illumination-light study system, and the objective lens and image formation aperture diaphragm which constitute image formation optical system. When adjusting using this adjusting device, an image formation aperture diaphragm is justified first, then an objective lens is justified, and, finally a lighting aperture diaphragm is justified. At this time, adjustment which carries out flattening of the convex configuration of QZ curve by justification of an image formation aperture diaphragm is performed, adjustment to which the inclination of QZ curve is changed by justification of an objective lens is performed, and adjustment which makes the parallel shift migration of the QZ curve carry out in the direction of Q value by justification of a lighting aperture diaphragm is performed. In addition, these justification may be automated.
[0012] The adjusting device concerning this invention branches from image formation optical system further, and the automatic focus equipment which performs automatic focus adjustment when photoing the image in which image formation was carried out by image formation optical system with said image pick-up equipment may be formed. In this case, automatic focus adjustment by automatic focus equipment is performed to the beginning, an image formation aperture diaphragm is justified to the second, an objective lens is justified to the third, and, finally a lighting aperture diaphragm is justified. These adjustments may be automated.
[0013] In addition, when Q value does not fall within a predetermined range after justifying a lighting aperture diaphragm at the end, automatic focus adjustment, justification of an image formation aperture diaphragm, justification of an objective lens, and justification of a lighting aperture diaphragm are again repeated in this sequence, and are performed, and adjustment which stores Q value in the predetermined range is performed.
[0014] Moreover, after justifying a lighting aperture diaphragm at the end, it is desirable for there to be a possibility that automatic focus adjustment may be out of order with this adjustment, and to perform again automatic focus adjustment by automatic focus equipment in this case.
[0015] The illumination-light study system in which the adjustment approach concerning this invention illuminates a measurement mark on the other hand, The image formation optical system to which the reflected light from a measurement mark is condensed and image formation of the image of a measurement mark is carried out, In the optical location gap measuring device constituted by having the image pick-up equipment

which photos the image of the measurement mark in which image formation was carried out by image formation optical system, and the image processing system which processes the picture signal acquired by image pick-up equipment, and measures a location gap of a measurement mark It is constituted so that two or more optical elements which constitute an illumination-light study system and image formation optical system may be justified in predetermined sequence and measurement error adjustment may be performed.
[0016]
[Embodiment of the Invention] Hereafter, the desirable operation gestalt of this invention is explained with reference to a drawing. An example of the optical location gap measuring device applied to this invention at drawing 1 is shown. In addition, for easy-izing of explanation, let into the direction of Y the direction which extends a direction perpendicular to space in X shaft orientations and right and left in drawing 1 , and let the direction which extends up and down be a Z direction.
[0017] The measuring device shown in drawing 1 measures a superposition location gap of the resist mark in the measurement mark 52 formed on the wafer 51, and is laid on the occasion of measurement on the stage 50 constituted by the wafer 51 possible [vertical migration (Z direction migration)] possible [rotation and horizontal migration (X-Y directional movement)]. The stage control section 55 is formed for migration control of such a stage. When making a predetermined resist pattern form according to a photolithography process on the substrate pattern of a wafer 51, the measurement mark 52 forms the rectangle-like resist mark 54 on Mark Shimoji 53 of the shape of a rectangle formed in the edge of a wafer 51 as shown in drawing 3 , is made, and it measures a superposition location gap of the resist mark 54 to Mark Shimoji 53 with the optical location gap measuring device concerning this invention.
[0018] The illumination-light study system 10 for this optical location gap measuring device to irradiate the illumination light at the measurement mark 52, The image formation optical system 20 to which the reflected light from a measurement mark is condensed and image formation of the image of a measurement mark is carried out, Thus, it has the image pick-up equipment 30 which photos the image of the measurement mark by which image formation was carried out, the image processing system 35 which processes the picture signal acquired by image pick-up equipment, and automatic focus equipment 40 which performs focusing control (focus control) in the image pick-up by image pick-up equipment 30.
[0019] First, the illumination-light study system 10 is equipped with the source 11 of the illumination light, the lighting aperture diaphragm 12, and a condenser lens 13, and the illumination-light bundle injected from the source 11 of the illumination light is extracted to a specific flux of light system by the lighting aperture diaphragm 12, it is inputted into a condenser lens 13 and condensed. The illumination light condensed by the condenser lens 13 illuminates a field diaphragm 14 to homogeneity. A field diaphragm 14 has the rectangle-like drawing opening S1 so that hatching may be performed and shown in drawing 1 . In addition, although the diaphragm opening S1 is expanded and shown in drawing 1 , like illustration, to the X-axis and the Z-axis, it inclines 45 degrees and is prepared aslant. In this illumination-light study system 10, the device (not shown) which justifies the lighting aperture diaphragm 12 (location of X-Z direction) is established for the measurement error adjustment mentioned later.
[0020] Incidence of the illumination light which penetrates the visual field opening S1 of a field diaphragm 14, and is injected is carried out to the lighting relay lens 15, and it carries out incidence to the 1st beam splitter 16 in the condition of it having been collimated by this lighting relay lens 15, and having become the parallel flux of light. Outgoing radiation is carried out caudad, it is condensed with the 1st objective lens 17, and the illumination light reflected in the 1st beam splitter 16 irradiates the measurement mark 52 on a wafer 51 perpendicularly. Here, the field diaphragm 14 and the measurement mark 52 are arranged in the location [****] in the illumination-light study system 10, and the field of the shape of a rectangle corresponding to the configuration of the visual field opening S1 is irradiated by the illumination light to the measurement mark 52 of a wafer 51.
[0021] Thus, the reflected light for which the illumination light is irradiated by the front face of the wafer 51 including the measurement mark 52 and which comes out is led to image pick-up equipment 30 through the image formation optical system 20. This reflected light is collimated by the 1st objective lens 17, serves as the parallel flux of light, passes the 1st beam splitter 16, and, specifically, forms the image of the measurement mark 52 in the primary image formation side 28 with the 2nd objective lens 21 arranged above the 1st beam splitter 16. Furthermore, the 1st image formation relay lens 22 is penetrated, a rat tail is formed by the image

formation aperture diaphragm 23, and the image of the measurement mark 52 is formed in the secondary image formation side 29 by the 2nd image formation relay lens 24 at the specific diameter of the flux of light. In this image formation optical system 20, the device (not shown) in which justification (location of the direction of X-Y) of the 2nd objective lens 21 and the image formation aperture diaphragm 23 is performed is established, respectively for the measurement error adjustment mentioned later.

[0022] CCD camera (image pick-up equipment) 30 is arranged so that this secondary image formation side 29 and the image pick-up side 31 may be in agreement, and the image of the measurement mark 52 is picturized by CCD camera 30. And signal processing is carried out so that the picture signal acquired by CCD camera 30 may be sent to an image processing system 35 and may mention later. The measurement mark 52 and the image pick-up side 31 are in physical relationship [****] so that this configuration may show.

[0023] The 2nd beam splitter 25 is arranged in the backside [the primary image formation side 28 of the image formation optical system 20], and automatic focus equipment 40 is formed in the location which receives the reflected light which branched by this 2nd beam splitter 25. In this automatic focus equipment 40, incidence of the flux of light which branched from the 2nd beam splitter 25 is carried out to the 1st relay lens 41 of AF, it is collimated, turns into the parallel flux of light, penetrates the parallel flat-surface glass plate 42, and carries out image formation of the image of the lighting aperture diaphragm 12 to the pupil division mirror 43. Focusing on shaft 42a perpendicular to space, tilt adjustment is possible for the parallel flat-surface glass plate 42, and it performs adjustment [in / for the parallel flux of light / the space of drawing 1] which carries out a parallel displacement up and down using optical refraction. The adjustment which carries out location ****** of the core of the image of the lighting aperture diaphragm 12 to the pupil division mirror 43 at the core of the pupil division mirror 43 is possible so that this may mention later.

[0024] In addition, although it indicates that the direction of a injection optical axis of the branching light from the 2nd beam splitter 25 becomes the optical axis of the illumination-light study system 10, and parallel in drawing 1 , the 2nd beam splitter 25 is arranged so that it may become actual in the direction to which it inclined 45 degrees on the X-Y flat surface to the illumination-light study system 10. That is, in Z ** (plane view), the optical axis of the illumination-light study system 10 and the optical axis of branching light make the include angle of 45 degrees. For this reason, the direction (this is called the measurement direction) shown by the arrow head A in a slit S1 turns into the vertical direction from the 2nd beam splitter 25 in drawing 1 in the path which results in the pupil division mirror 43, and the direction (this is called the non-measuring direction) shown by the arrow head B turns into a direction perpendicular to the space in drawing 1 .

[0025] Thus, the parallel flux of light which carried out incidence to the pupil division mirror 43 is halved in the measurement direction, is divided into the two flux of lights L1 and L2, and carries out incidence to the 2nd relay lens 44 of AF. And after being condensed by the 2nd relay lens 44 of AF, it is completed in the non-measuring direction by the cylindrical lens 45 which shows a convex lens configuration to the space in drawing 1 in a right-angled cross section. Since a cylindrical lens 45 does not have refractive power in the longitudinal direction in space, the two above-mentioned flux of lights L1 and L2 carry out image formation of the light source image, respectively on the AF sensor 46 which is condensed in the measurement direction (space inboard) by the 2nd relay lens 44 of AF, and consists of a line sensor.

[0026] Thus, although two light source images carry out image formation on the AF sensor 46, the condition (drawing 2 (A)) from which the image formation location shifted to the front [sensor / 46 / AF] side at drawing 2 , the condition (drawing 2 (B)) which focused on the AF sensor 46, and the condition (drawing 2 (C)) of having shifted at the backside [sensor / 46 / AF] are shown. As shown in drawing 2 (B), after two light source images have focused, the location is beforehand made so that the image of a wafer 51 may focus to CCD camera 30, and if it shifts from a focus location, the center position P1 of two light source images on the AF sensor 46 and the distance between P2 will become narrow, or will become large.

[0027] For example, when the stage 50 in which a condition to the wafer 51 with which the image of a wafer 51 focused to CCD camera 30 was laid is moved caudad, as it is shown in drawing 2 (A), an image formation location shifts to a front [sensor / 46 / AF] side, and the distance between two center positions of a light source image approaches. On the other hand, when the stage 50 in which a condition to the wafer 51 with which the image of a wafer 51 focused to CCD camera 30 was laid is moved up, as it is shown in drawing 2 (C), an image formation location shifts to the backside [sensor / 46 / AF], and the distance between two center positions of a light source image separates.

[0028] The detecting signal of the AF sensor 46 is sent to AF signal-processing section 47, and the distance between the center positions of two light source images by which image formation was carried out on the AF sensor 46 here is computed. And as compared with the pitch in the focus condition by which measurement storage is beforehand carried out in this pitch, the difference of both distance is calculated and it outputs to the stage control section 55 as focal positional information. Namely, the measurement storage of the distance between the center positions of two light source images on the AF sensor 46 in the condition that the image of a wafer 51 focused to CCD camera 30 is carried out beforehand, and the difference of this and the actually detected pitch is a difference with a focus condition, and outputs to the stage control section 55 by making this difference into focal positional information. And in the stage control section 55, a stage 50 is made to go up and down so that the above-mentioned difference may be abolished, and the adjustment which vertical migration of the wafer 51 is carried out [adjustment], and makes the image focus to CCD camera 30, i.e., automatic focus adjustment, is performed.
[0029] In addition, two light source images which do in this way and are used for automatic focus adjustment are made from the flux of light from the long slit S1 in the non-measuring direction (the direction of B) formed in the field diaphragm 14, as shown in drawing 1 . At this time, the flux of lights L1 and L2 which spread in the non-measuring direction converge by the cylindrical lens 45, and are collected on the AF sensor 46. The reflective nonuniformity from the front face of a wafer 51 can be equalized by this, and the detection precision by the AF sensor 46 improves.
[0030] Next, the location gap measurement by the optical location gap measuring device of the above configurations is explained. For this location gap measurement, the measurement mark 52 is formed in the wafer 51. This measurement mark 52 consists of resist marks 54 formed on Mark Shimoji 53 at formation and coincidence of a resist pattern in Mark Shimoji 53 who consists of a crevice of the shape of a rectangle formed in the front face of a wafer 51, and a photolithography production process, as shown in drawing 3 . In a photolithography production process, the resist mark 54 is set up so that it may be located and formed in Mark Shimoji's 53 center, and the amount of location gaps of the resist mark 54 to Mark Shimoji 53 is equivalent to the amount of superposition location gaps of the resist pattern to a substrate pattern. For this reason, as shown in drawing 3 , the spacing R of Mark Shimoji's 53 center line C1 and the center line C2 of the resist mark 54 is measured with the optical location gap measuring device of the above-mentioned configuration as an amount of superposition location gaps. In addition, although the amount R of superposition location gaps shown in drawing 3 is the amount of location gaps of Y shaft orientations (longitudinal direction), the amount of location gaps of this and the direction of a right angle, i.e., X shaft orientations, (lengthwise direction) is measured similarly.
[0031] Thus, when measuring the amount R of superposition location gaps in the measurement mark 52 and aberration and aberration symmetrical with nonrotation exist in a measuring beam study system (namely, the illumination-light study system 10 and image formation optical system 20) especially, there is a problem that a measurement error TIS is included in the measured value of this amount R of superposition location gaps. This measurement error TIS is explained briefly. This measurement performs the measurement mark 52 about the two directions of 0 times and 180 degrees, as shown in drawing 4 (A) and (B). Namely, first, as are shown in drawing 4 (A), and the amount R0 of superposition location gaps of the resist mark 54 to Mark Shimoji 53 is measured in the condition that location mark 53a shown virtually is located in the left and it is shown in drawing 4 (B) below The measurement mark 52 is rotated 180 degrees, the amount R180 of superposition location gaps is measured in the condition that virtual location mark 53a is located in the right, and a measurement error TIS is calculated by the degree type (1).
[0032]
[Equation 1]
$TIS = (R0+R180)/2 \ldots (1)$
[0033] As shown in a formula (1), even if there is a superposition location gap of the resist mark 54 to Mark Shimoji 53, the measurement error TIS calculated by the formula (1) should become zero theoretically. However, when optical aberration, especially aberration symmetrical with nonrotation are in a measuring beam study system, even if it rotates the measurement mark 52 180 degrees as mentioned above, in order not to necessarily rotate this aberration, the value only corresponding to the effect of aberration is calculated as a measurement error TIS from the count result of a formula (1).

[0034] In having measured the amount R of superposition location gaps with the optical location gap measuring device mentioned above, with the measurement error TIS included generated according to such optical aberration, the exact amount R of superposition location gaps cannot be measured. For this reason, in the optical location gap measuring device concerning this invention, it is made to perform adjustment which suppresses the effect of the above-mentioned measurement error TIS as much as possible. Furthermore, the center position doubling adjustment to the pupil division mirror 43 in automatic focus equipment 40 is also required, and these adjustments are explained below.

[0035] Adjustment of automatic focus equipment 40 is performed first. As mentioned above, when being divided into the two flux of lights L1 and L2 by the pupil division mirror 43, if the quantity of light of both the flux of lights L1 and L2 is not equal, there is a possibility that automatic focus adjustment may become inaccurate. For this reason, making in agreement with the core of the pupil division mirror 43 the core of the image of the lighting aperture diaphragm 12 by which image formation was carried out to the pupil division mirror 43 is searched for so that the quantity of light of both the flux of lights L1 and L2 may become equal.

[0036] Here, the condition that the image of the slit S1 of a field diaphragm 14 carried out image formation is shown in the AF sensor 46 at drawing 5 (A), and as shown in this drawing, image formation of the two images IM (L1) and IM (L2) is carried out. Thereby, the AF sensor 46 detects these two images, and outputs a profile signal as shown in drawing 5 (B). If division by the pupil division mirror 43 shifts and a difference is in the quantity of light of both the flux of lights L1 and L2, as shown in drawing 5 (B), difference deltai will occur in the profile signal strength i (L1) and i (L2). The way things stand, there is a possibility that measurement of the distance D between two center positions of an image may become incorrectness. For this reason, when signal strength difference deltai is detected in this way, tilt adjustment of the parallel flat-surface glass plate 42 is performed, and the adjustment to which the parallel displacement of the main optical-axis location of the flux of light which carries out incidence to the pupil division mirror 43 is made to carry out in the vertical direction in drawing 1 , i.e., the adjustment made in agreement with the core of the pupil division mirror 43, is performed so that this difference may be abolished. Thus, if it is made for the quantity of light of the flux of lights L1 and L2 to become equal, adjustment of automatic focus equipment 40 will be completed.

[0037] Next, adjustment to the effect of a measurement error TIS is performed. This adjustment is performed by justification of the lighting aperture diaphragm 12, the image formation aperture diaphragm 23, and the 2nd objective lens 21. This adjustment replaces a wafer with the last shipment mark 60 of a configuration as shown in drawing 6 with the wafer 51 in the equipment shown in drawing 1 , lays it on a stage 50, and is performed by carrying out the image processing of the last shipment mark image which illuminated the last shipment mark 60 by the illumination-light study system 11, and was picturized by CCD camera 30. two or more lines which are 0.085 micrometers (about [of the exposure light lambda / 1/8]) in the line breadth of 3 micrometers, and level difference, and are prolonged in parallel of pitch 6micrometer as this last shipment mark 60 is shown in drawing 6 (A) and (B) -- it is the mark which consists of marks 61-67.

[0038] When the last shipment mark image picturized by CCD camera 30 is processed with an image processing system 35 and it asks for picture signal reinforcement, the profile comes to be shown in drawing 6 (C). here -- each -- a line -- although signal strength falls in the level difference location of marks 61-67 -- each -- a line -- the Q value (Q= 1 / 7xsigma (deltaI/I)x100 (%)) which shows the sex for un-of a last shipment mark image is calculated by asking for signal strength difference deltaI in the level difference location of the right-and-left both sides in every mark, and averaging this about the whole-line-like marks 61-67. Next, if a stage 50 is moved in the vertical direction (Z direction), the last shipment mark 60 is moved to a Z direction and each height location (Z direction location) of every is asked for the focal property of Q value in quest of Q value, QZ curve as shown, for example in drawing 7 will be obtained.

[0039] Two kinds of QZ curves (1), i.e., QZ curve, and QZ curve (2) are shown in drawing 7 , and, in the case of QZ curve (1), aberration symmetrical [aberration symmetrical with nonrotation is large, and] with nonrotation when it is QZ curve (2) is small. For this reason, it is thought that what is necessary is just to perform adjustment which serves as QZ curve (2).

[0040] It explains briefly [below] about such adjustment (this is called QZ adjustment). Although this adjustment is performed by justification of the lighting aperture diaphragm 12, the image formation aperture diaphragm 23, and the 2nd objective lens 21 as mentioned above, the change property of QZ curve for every justification is shown in drawing 8 . First, if the lighting aperture diaphragm 12 is justified, as an arrow head A

shows, it will become the adjustment which carries out parallel shift migration of the QZ curve up and down at drawing 8 (A). As shown in this drawing, the maximum Q value of each QZ curve, i.e., a shift amount required to carry out a parallel displacement to the Z-axis, is called shift-amount alpha. If the image formation aperture diaphragm 23 is justified, as an arrow head B shows, it will become the adjustment which carries out flattening of the convex configuration of QZ curve at drawing 8 (B). As shown in this drawing, it projects and the amount of the maximum protrusions of each QZ curve is called an amount beta. If the 2nd objective lens 21 is justified, as an arrow head C shows, it will become the adjustment to which whenever [tilt-angle / of QZ curve] is changed at drawing 8 (C). As shown in this drawing, it inclines and the difference of the maximum minimum value of each QZ curve is called an amount gamma.

[0041] In this invention, the change property of QZ curve accompanying such adjustment is taken into consideration, and the adjustment approach which becomes the most appropriate [adjustment] and easy is performed. In the condition which assembled mechanically the optical location gap measuring device of a configuration of being shown in drawing 1 as the design value, and has generally arranged it to it here, QZ property is in the condition which collapsed greatly, for example, is a property like the line shown by QZ (1) in drawing 9 . In order to change into a condition like QZ curve (2) which shows this in drawing 7 , it adjusts in the sequence shown below.

[0042] First, the image formation aperture diaphragm 23 with sensitive adjustment sensibility is adjusted. This adjustment is adjustment which carries out flattening of the convex configuration, as shown in drawing 8 (B), and as an arrow head B shows drawing 9 , it performs adjustment made into the curve shown by QZ (3) from the curve shown by QZ (2). This adjustment is performed so that the amount beta of protrusions to the 1st datum line BL (1) which connects the both ends of each [these] QZ curve may be made into predetermined within the limits (for example, less than **0.5%).

[0043] Next, the 2nd objective lens 21 is justified. This adjustment is adjustment to which the inclination of QZ curve is changed, as shown in drawing 8 (C), and as an arrow head C shows drawing 9 , it performs adjustment to which the inclination of Curve QZ (3) by which flattening was carried out is horizontally changed as QZ (4) shows. Here, since flattening (straight-line-izing) of the QZ curve is carried out by justification of the image formation aperture diaphragm 23 before this adjustment, it is possible to perform this slope regulation exactly. This adjustment is performed so that the amount gamma of inclinations to the 2nd datum line BL (2) which is level Rhine passing through the center position of Curve QZ (4) may be made into predetermined within the limits (for example, less than **1.0%).

[0044] By two above-mentioned adjustments, it will be in the condition near a straight line parallel to the Z-axis as [show / QZ (4)], and spacing of this and the Z-axis shows the amount of location gaps of the lighting aperture diaphragm 12. Then, the lighting aperture diaphragm 12 is justified, and as an arrow head A shows drawing 9 , adjustment which carries out parallel shift migration of the curve QZ (4) which became level straight line-like with QZ (5) to QZ (6) is performed. This adjustment is performed so that shift-amount alpha of Curve QZ (6) may be made into predetermined within the limits (for example, less than **0.5%). Consequently, the small property of the aberration symmetrical with nonrotation shown by QZ (6) is acquired.

[0045] In addition, the adjustment sensibility of the lighting aperture diaphragm 12 is blunter than other two adjustment sensibility (the image formation aperture diaphragm 23 and adjustment sensibility of the 2nd objective lens 21), and even if the location of the lighting aperture diaphragm 12 has shifted somewhat, the variation of the parallel shift amount used as the decision index is small. For this reason, if it is not after performing two adjustments of these others, it is difficult to judge correctly the amount of adjustments of the lighting aperture diaphragm 12. Since it is such, it is made to adjust the lighting aperture diaphragm 12 at the end.

[0046] In the above-mentioned adjustment, since the illumination-light study system 10 is making the optical path of automatic focus equipment 40 serve a double purpose, adjustment of automatic focus equipment 40 is influenced by adjustment of the above-mentioned lighting aperture diaphragm 12. For this reason, after the above-mentioned adjustment is performed, adjustment (tilt adjustment of the parallel flat-surface glass plate 42) of automatic focus equipment 40 is performed again.

[0047] If it collects above, adjustment of automatic focus equipment 40 and QZ adjustment will be performed by the following procedures.

[0048]

[Table 1] (1) Tilt adjustment of the parallel flat-surface glass plate 42 in automatic focus equipment 40 (2) Adjustment of the image formation aperture diaphragm 23 (3) Adjustment of the 2nd objective lens 21 (4) Adjustment of the lighting aperture diaphragm 12 (5) Tilt adjustment of the parallel flat-surface glass plate 42

[0049] In adjustment of one-time above-mentioned (1) - (4), when not entering in quantitive specification with the Q value in the property shown with QZ curve, adjustment of above-mentioned (1) - (4) is repeated until it enters in specification.

[0050] It may be made to carry out by automating the adjustment explained above, and this example is explained with reference to the flow chart of drawing 10 and drawing 11 . In addition, in both [these] drawings, round-head enclosure sign A is connected and one flow chart is constituted.

[0051] Automatic focus adjustment is performed first (step S1). However, this is performed automatically literally originally. Next, the image formation aperture diaphragm 23 is adjusted (steps S2 and S3). Asking for QZ curve, this adjustment performs adjustment made into the curve shown by QZ (3) from the curve shown by QZ (2), as an arrow head B shows drawing 9 . This adjustment is performed until it considers beta as the less than **1% of the amounts of protrusions to the 1st datum line BL (1) which connects the both ends of each [these] QZ curve.

[0052] Next, the 2nd objective lens 21 is justified (step S4 and S5). Asking for QZ curve, this adjustment performs adjustment to which the inclination of Curve QZ (3) by which flattening was carried out is horizontally changed as QZ (4) shows, as an arrow head C shows drawing 9 . This adjustment is performed until it makes the amount gamma of inclinations to the 2nd datum line BL (2) into less than 2%.

[0053] And the lighting aperture diaphragm 12 is justified (steps S6 and S7). Asking for QZ curve, this adjustment performs adjustment which carries out parallel shift migration of the curve QZ (4) which became level straight line-like with QZ (5) to QZ (6), as an arrow head A shows drawing 9 . This adjustment is performed until it makes shift-amount alpha into less than 1%.

[0054] By the above, although primary adjustment is completed, automatic focus adjustment may shift by adjustment of the lighting aperture diaphragm 12, and automatic focus adjustment is again performed in step S8. When the above adjustment is performed, it judges whether whether shift-amount alpha is [the amount gamma of inclinations] less than 0.5% within 1%, the amount beta gamma of protrusions of inclinations, i.e., the amount, and shift-amount alpha are settled within the limits of predetermined at the less than beta**0.5% of the amounts of protrusions (step S9). Thus, if it has ****ed within the limits of predetermined, since the adjustment beyond this is unnecessary, regulating completion of it will be carried out.

[0055] On the other hand, when not settled within the limits of predetermined, secondary adjustment not more than step S10 is performed. It starts from adjustment of the image formation aperture diaphragm 23 in steps S10 and S11, and this adjustment considers beta as the less than **0.5% of the amounts of protrusions of QZ curve here. Next, it progresses to step S12 and step S13, the 2nd objective lens 21 is justified, and the amount gamma of inclinations of QZ curve is made into less than 1% here. Furthermore, it progresses to steps S14 and S15, the lighting aperture diaphragm 12 is justified, and shift-amount alpha of QZ curve is made into less than 0.5% here.

[0056] Then, automatic focus adjustment is performed again (step S16), and it judges whether whether shift-amount alpha is [the amount gamma of inclinations] less than 0.5% within 1% at the less than beta**0.5% of the amounts of protrusions, the amount beta gamma of protrusions of inclinations, i.e., the amount, and shift-amount alpha are settled within the limits of predetermined in step S17. Thus, when not restored to predetermined within the limits, the return above-mentioned secondary adjustment is again performed to step S10. This regulating automatically will be completed if it is checked that it has been restored to predetermined within the limits.

[0057]

[Effect of the Invention] The illumination-light study system which illuminates a measurement mark according to this invention as explained above, The image formation optical system to which the reflected light from this measurement mark is condensed, and image formation of the image of a measurement mark is carried out, The image pick-up equipment which photos the image of the measurement mark in which image formation was carried out by this image formation optical system, In the optical location gap measuring device constituted by having the image processing system which processes the picture signal acquired by this image pick-up equipment, and measures a location gap of a measurement mark An adjusting device and the adjustment

approach are constituted so that an optical element nothing and multiple [these] may be justified for justification of two or more optical elements which constitute an illumination-light study system and image formation optical system in predetermined sequence with it being possible and measurement error adjustment may be performed.
[0058] If adjustment of adjustment elements, such as a lighting aperture diaphragm, an image formation aperture diaphragm, and an objective lens, is performed according to predetermined sequence according to such this invention, the measurement error TIS which adjusts simply and correctly also including adjustment of automatic focus optical system is removable. Moreover, it is the adjustment performed according to predetermined sequence in this way, and it is easy to automate this.

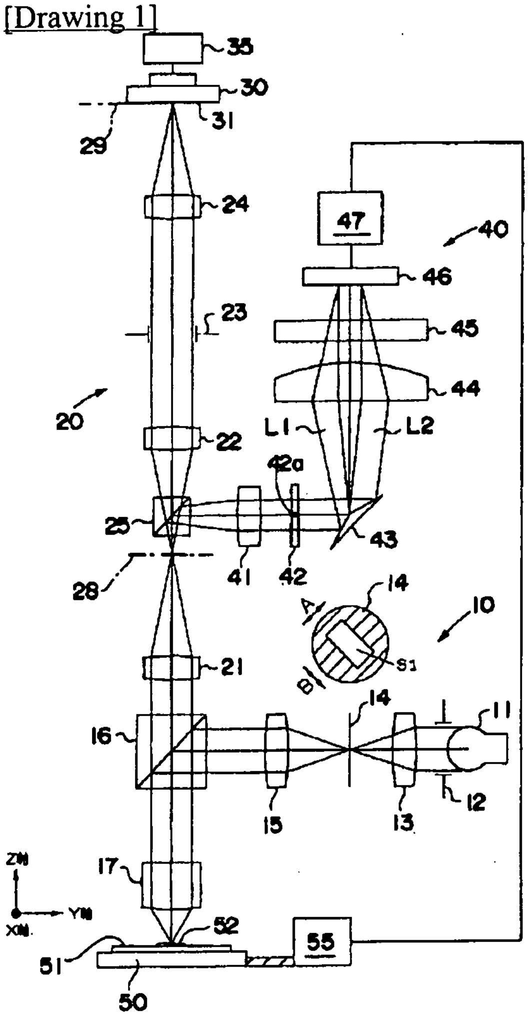
[Translation done.]

* NOTICES *

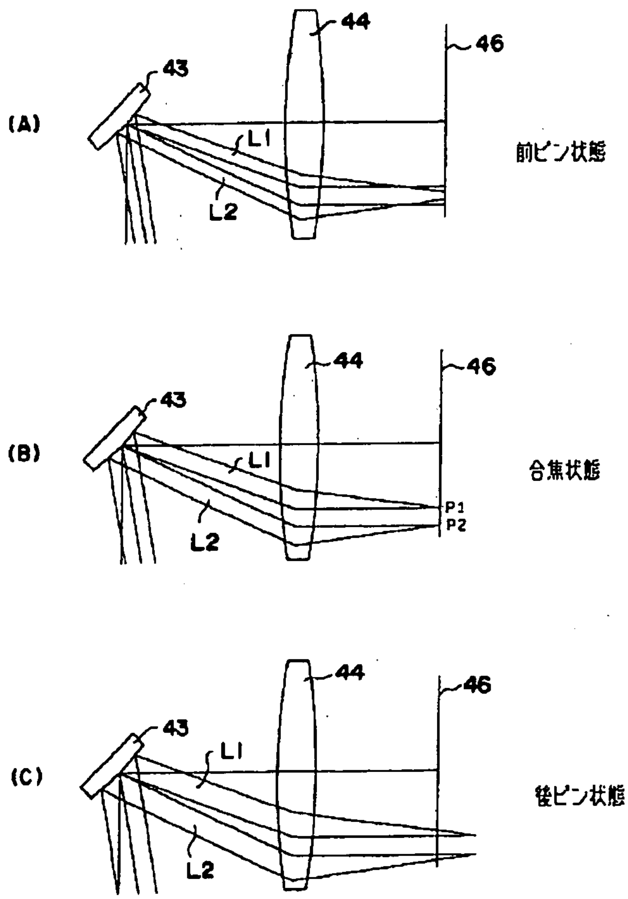
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

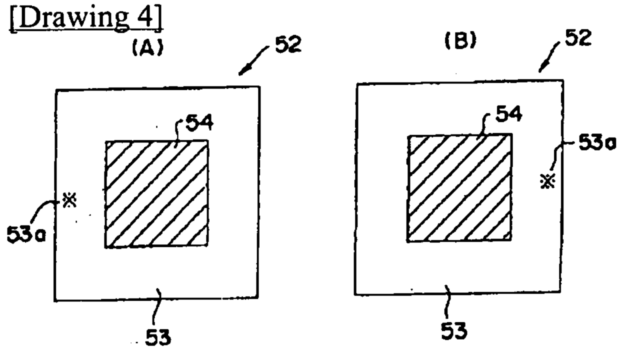
[Drawing 1]



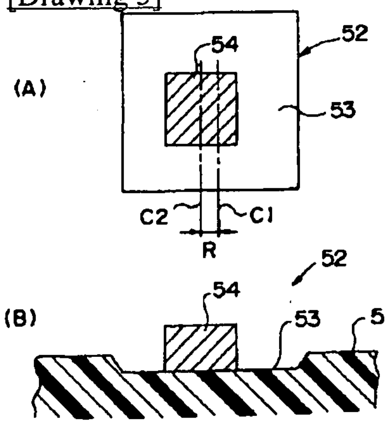
[Drawing 2]



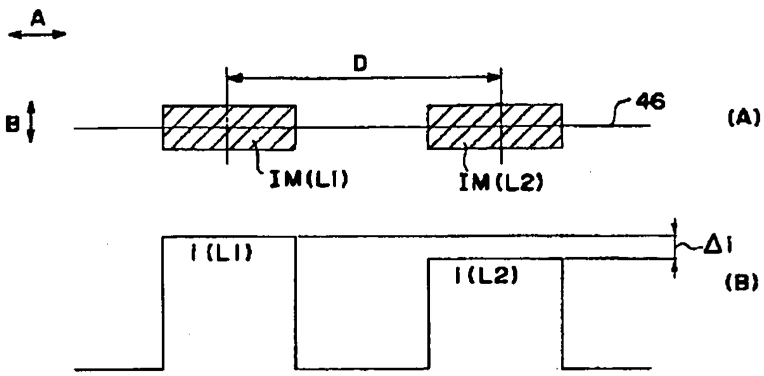
[Drawing 4]



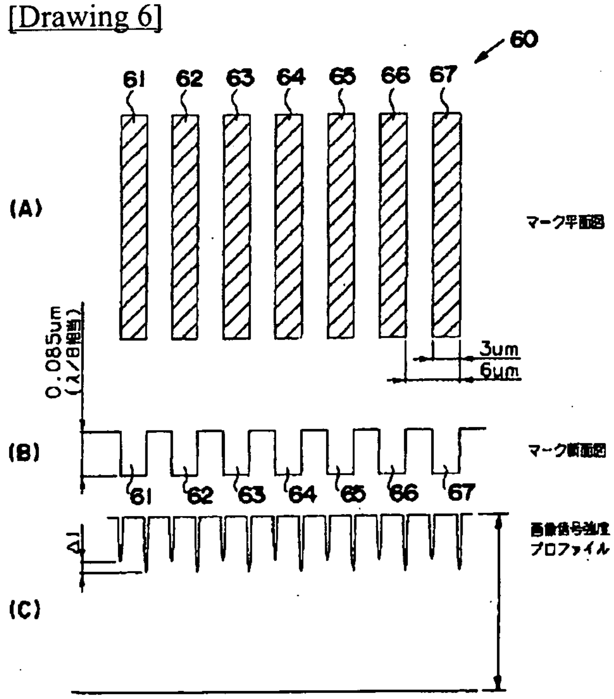
[Drawing 3]



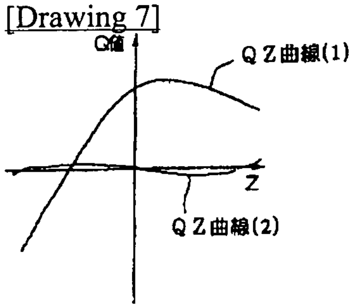
[Drawing 5]



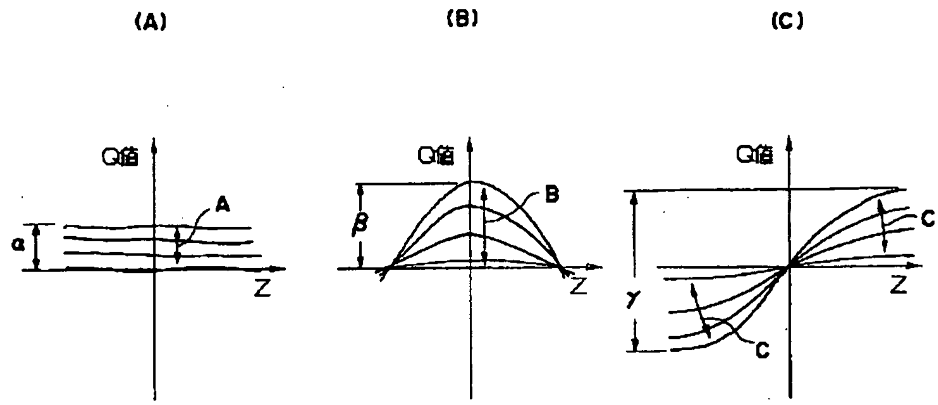
[Drawing 6]



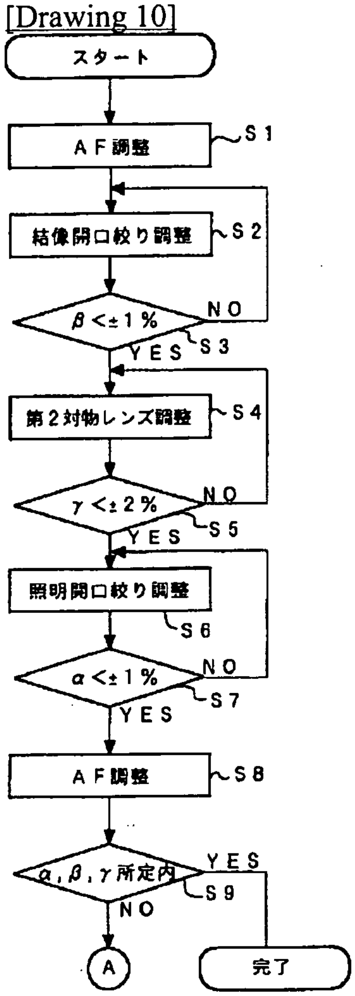
[Drawing 7]



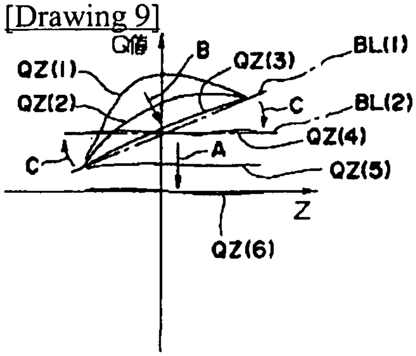
[Drawing 8]



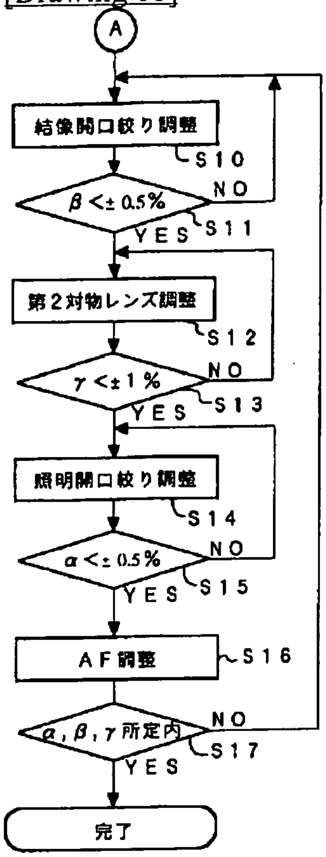
[Drawing 10]



[Drawing 9]



[Drawing 11]



[Translation done.]